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FRANKLIN INSTITUTE

THE REVOLVING PURIFIER

(ANDERSON'S PATENT).

AN APPARATUS WHICH EFFECTS THE

PURIFICATION OF RIVER WATER AND SEWAGE EFFLUENT

AND THE ENTIRE

REMOVAL OF COLOUR FROM WATER CONTAINING PEAT OR CLAY,

BY MEANS OF

AGITATION WITH METALLIC IRON.

INVENTIONS EXHIBITION,
GOLD MEDAL,
LONDON, 1885.

INTERNATIONAL EXHIBITION,
MEMBER OF JURY,
ANTWERP, 1885.

REVOLVING PURIFIER COMPANY, LIMITED,
DOCK HOUSE, BILLITER STREET,
LONDON, E.C.

1889.

ID 37-89685 TCE

INSTITUTION OF MECHANICAL ENGINEERS.

SPRING MEETING, 1889.

Extract of Address by the President, Charles Cochrane, Esq.

"Great work has already been accomplished in the direction of sanitary improvements by the provision of abundant supplies of fresh water to many of our towns and cities; and our Institution has been privileged to visit some of the largest waterworks at Glasgow, Edinburgh, Dublin, and Manchester, whilst still larger are in progress for the supply of Liverpool from the mountains of Wales, and for the further supply of Manchester from Lake Thirlmere. Unquestionably it is better to obtain pure water at its source; but what it will cost is always the precedent inquiry; and it may be well to ask whether the more or less contaminated water of our rivers can be purified, so as to be made really potable.

"In 1883 our members were invited, on the occasion of our memorable visit to Belgium, to see an attempt there in progress to accomplish the purification of the water for the supply of Antwerp. Few, I fear, were able to avail themselves of the opportunity thus afforded to see the attempted application on a large scale of Professor Bischof's system of purification by means of spongy iron, which has been worked out so successfully on the small scale of domestic filters. Though correct in principle, the application of the spongy iron over large areas led after some months to the obstruction of the filter-beds, and would have compelled the abandonment of the system, had it not been for the bold and radical change which it occurred to our Vice-President, Mr. William Anderson, to introduce. The spongy iron was removed from the filter-beds, and the reservoirs containing it were transformed into sand filter-beds, on which oxide of iron speedily forms, and plays an important part in the purification of the water passing through it. Sir Frederick Abel appears to have suggested the application of ordinary metallic instead of spongy iron, and Mr. Anderson seems to have worked out the idea most successfully in his application of what is known as the Revolving Iron Purifier, which has now been in operation for

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over three years at Antwerp. On the authority of Professor Ad. Kemna, who was appointed chemist to the waterworks, I am able to state that so complete is the satisfaction given that similar means are now in operation at Gouda, and at Dordrecht in Holland, and at the Establishment Cail, Quai de Grenelle, in Paris. Experiments on a large scale have been made at Ostend, Berlin, and in London. In view of the success attained in purifying the water supplied to Antwerp, Professor Kemna is hopeful that by the employment of those revolving cylinders it will be possible to render inodorous the effluents of the sewers, and thereby make them sufficiently pure to deliver into streams or rivers without serious consequences. On the authority of Mr. Anderson, I learn that the system is to be applied at Baroda in India, and that the municipality of Agra has adopted it for purifying the waters of the Jumna, and that the town of Libourne in France is also applying it. It is an interesting circumstance in connection with the purity of the water now obtainable at Antwerp, that some of the steamers sailing thence to New York take in a supply for the double voyage, in preference to refilling from the Croton aqueduct at New York for the return voyage."

THE REVOLVING PURIFIER

(ANDERSON'S PATENT).

INTRODUCTORY REMARKS.

THE truth of the proverb which tells us that "Necessity is the mother of invention" could hardly be better illustrated than by recalling the circumstances which led Mr. William Anderson* to the invention of the Revolving Purifier. When constructing the works which were to supply the city of Antwerp, in Belgium, with water, the inventor's firm, Messrs. Easton and Anderson, had to accept as the source of supply, the River Nethe, a tidal river fed during the rainy season by surface water and springs, much discoloured by their contact with peat and clay, and to a large extent draining off the highly cultivated districts of the north-east of Belgium. Although allowed by the municipal authorities to utilise the Nethe water, after submitting it to the ordinary process of sand filtration, the concessionaires of the water supply of Antwerp found that such filtration was altogether inadequate to remove the yellow colour and opalescence which are the distinctive mark of water of this nature. Knowing the remarkable properties of metallic iron as used in Professor Bischof's domestic filters in the prepared form called "spongy iron," it was determined, after experiments made on the spot, to utilise this patent material on a large scale, and to construct filter-beds composed of a layer of spongy iron, 3 feet thick. This was accordingly done, some 900 tons of the prepared iron being mixed with three times its bulk of fine gravel. The first two years' working of these new filters gave the most excellent results, and both the inventor of the spongy iron and the engineers of the works believed that a practical system had been found of effectually clarifying and purifying discoloured and impure river water. Their expectations were, however, doomed to disappointment.

As the demand for water in the city increased, and the filters required to deliver a considerable and regular volume of water every day, it was found that the bed of spongy iron was, in spite of the large proportion of gravel mixed with it, gradually choking up. The powerful chemical action of the metal on the dissolved matters contained in the Nethe, while purifying the water in a most remarkable way, was itself the cause of the most serious practical difficulties, the delivery of the filters diminishing at a constantly increasing rate, and finally rendering it necessary to loosen and break up at frequent intervals the whole mass of the iron and gravel mixture, some 2000 tons in weight, in order to obtain the necessary daily supply.

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* Director-General of Government Ordnance Factories, Member of Council Inst. Civ. Eng., Member of Council Society of Arts, Consulting Engineer R.A.S.E., &c., &c.

Towards the end of the year 1884 matters had become so bad, and the cost of working the spongy iron filters so heavy, as to condemn their practical use on the large scale. It was then that, after the Waterworks Company and their engineers had consulted several of the most eminent chemists, Sir Frederick Abel made a suggestion which Mr. Anderson succeeded in putting into practice, and of which the Revolving Purifier is the outcome. Recognising the invaluable properties of iron as a purifier of water, Sir Frederick Abel pointed out that what was necessary to practically make use of this material with large volumes of water was to keep the particles of iron separate by continuous agitation, so as to prevent the metal from forming into an impervious mass, and to allow the oxides of iron and the precipitate formed by the chemical action to be carried through the purifying medium.

This result Mr. Anderson has succeeded in obtaining by the Revolving System of Purification which we are about to describe, and the invention of the apparatus led to the discovery firstly, that ordinary waste iron, such as cast-iron borings or plate punchings, when thus applied were as effective purifiers of impure water as the more costly prepared forms of the metal; and secondly, that the duration of contact between iron and water necessary for efficient purification could be reduced from 45 minutes to 3½ minutes when the two were brought into that intimate contact which the Revolving Purifier ensures.

For more detailed information as to the original system of filtration through spongy iron, the difficulties it gave rise to, and the final mastery of these difficulties by the introduction of the Revolving Purifier, we would refer our readers to :—

'Minutes of Proceedings of the Institution of Civil Engineers,' vol. lxxxi., Session 1884–85, *part iii.—I. "The Purification of Water by means of Iron on the Large Scale." By William Anderson, M. Inst. C.E. II. "The Purification of Water by Metallic Iron in Mr. Anderson's Revolving Purifier." By George Henry Ogston, F.C.S., Assoc. M. Inst. C.E.*

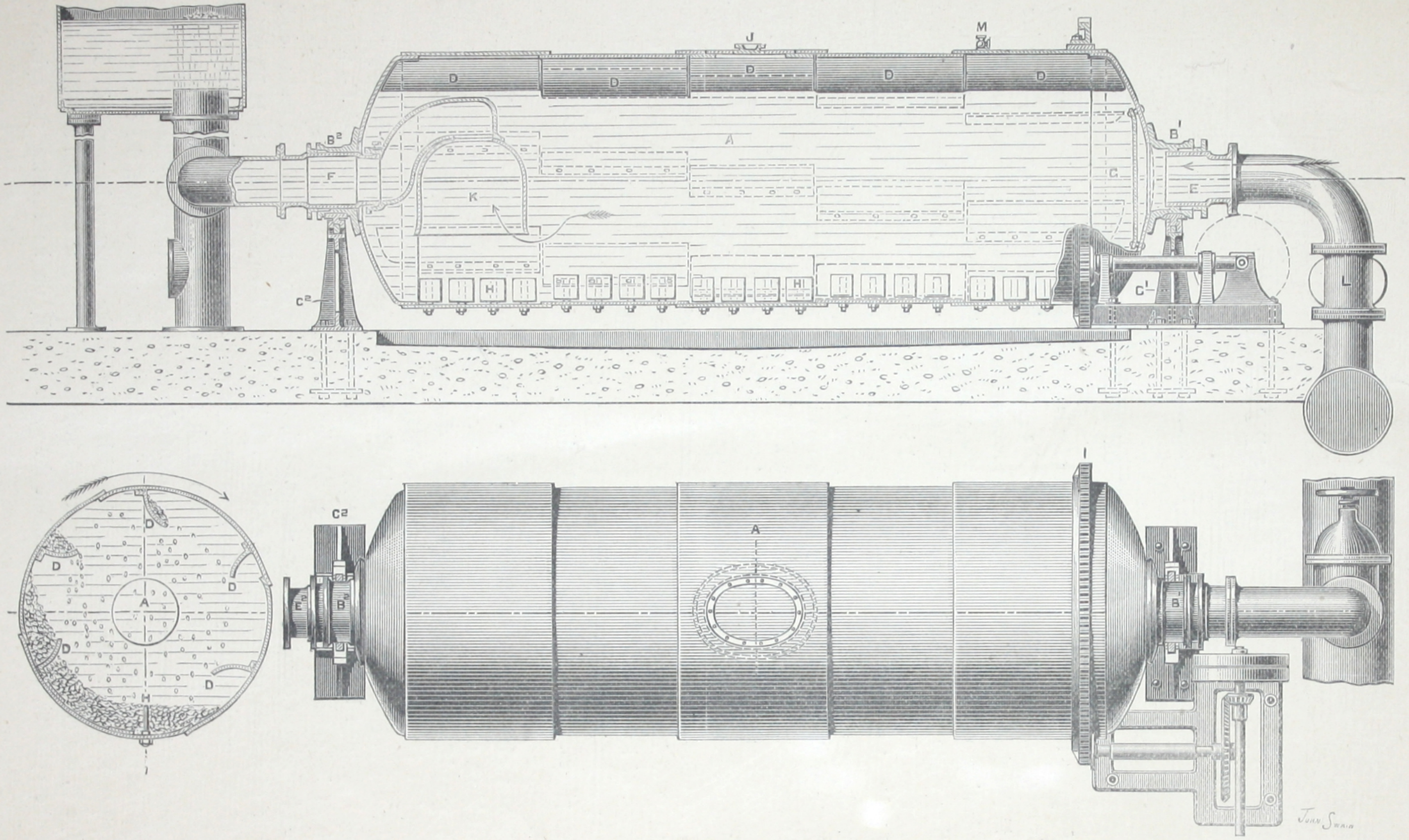
'Journal of the Society of Arts,' Nov. 26, 1886, *vol. xxxv.—"The Purification of Water by Agitation with Iron and by Sand Filtration." By W. Anderson, M. Inst. C.E.*

"L'Application Pratique du Fer à la Purification des Eaux Alimentaires." Par E. Devonshire, Assoc. M. Inst. C.E., Ingénieur de la Société des Travaux d'Eau d'Anvers.

"Ville d'Anvers: Rapport sur l'Eau de la Distribution pendant l'Été de 1885."

"Three Years' Experience of Water Purification by means of Iron in Anderson's Revolving Iron Purifier." By E. Devonshire, Assoc. M. Inst. C.E., Resident Engineer and Manager to the Antwerp Waterworks Company, Limited. London, 1888.

PLATE I.



PLAN AND ELEVATION OF THE PATENT REVOLVING PURIFIER.

CHAPTER I.

DESCRIPTION OF THE APPARATUS.

Convenience of rivers.

THE frequent failure of the supply of water for large towns brings yearly into more prominence the advantage of being able to make use of the practically inexhaustible quantity of water to be found in the rivers on which most of such towns are situated, could the pernicious effects of the contamination of this source of supply, by the admission into their stream of sewage effluents and other waste waters, be safely, effectually, and cheaply counteracted by a system of purification. Sand filtration alone has been found insufficient, as its purifying effects upon organic impurities is almost nil, and in many cases, particularly in those where the river flows over peaty or clayey soils, colour is not entirely removed even by the slowest filtration.

Sand filtration insufficient.

Purifying power of metallic iron.

The remarkable effect of metallic iron upon organic matter, and its property of removing colour from peaty water, has long been known. Until recently, however, its practical application to large volumes of water has remained an insuperable difficulty, the metal having been used as a filtering medium, in which form it becomes rapidly caked together and loses its permeability after a few months' working. Anderson's Patent Revolving Purifier has been designed to overcome these difficulties, and its success has now been proved by a more or less extended experience of its application on the large scale at Antwerp, in Belgium; Dordrecht, Gouda, in Holland; at Paris, Nancy, and Libourne, in France; and at Baroda and Agra, in India; in all of which places, Paris and Nancy excepted, the whole water supply is being purified by this process.

Principle of Revolving Purifier.

The principle of the Patent Revolving Purifier consists in the production of an intimate contact between metallic iron and the liquid to be purified, by the showering down of finely divided particles of the metal through an onward flowing stream of the liquid.

Description.

The apparatus itself, as represented in Plate I., consists of a cylinder A, supported in a horizontal position by hollow trunnions B_1 B_2 revolving in pedestal bearings C_1 C_2, placed one at each of its extremities. Within the cylinder are a series of short curved shelves D D D arranged in steps at equal distances round its circumference and reaching from end to end. In the place of a sixth row of curved shelves is a line of small square plates H H H, which, by means of nuts outside the cylinder, can be set at an angle with the axis of the purifier. These plates serve to direct the shower of iron back towards the inlet end of the apparatus, and so to counteract the tendency of the current of water to carry the purifying material forward. Through the hollow trunnions, which are provided with stuffing boxes, pass the ends of inlet and outlet pipes E and F, which bring and which carry off the water to be purified. Facing the inlet pipe E, is a circular distributing plate G, secured at a distance of $\frac{5}{8}$ inch or $\frac{3}{4}$ inch from the end of the cylinder, serving to distribute the water radially on its entering the cylinder, and prevent its flowing in a direct current along the axis of the apparatus. The inner end of the outlet pipe is fitted with an inverted bell-mouth K, carried down as near to the bottom of the cylinder as the shelves will allow, and intended to prevent the finer particles of iron from being carried out by the current of water. A rotary motion is given to the cylinder through gearing working into an annular spur-wheel I, surrounding one end of the cylinder.

Through a suitable hand- or man-hole J, iron in a moderately fine state of division is introduced into the cylinder and spread evenly along the bottom in sufficient quantity to occupy one-tenth of the capacity of the cylinder.

Method of working.

When the Revolving Purifier is to be set in motion, the sluice-cock L, provided at the inlet, is opened and the cylinder filled with water, the air being expelled through the air-cock M, which at that time must be at the top of the cylinder. When all the air is expelled the air-cock is shut, and the apparatus is set in motion by a small steam-engine or other suitable form of motor, the speed of rotation being about 6 feet per minute at the periphery. By this rotary movement the shelves are successively caused to scoop up the iron granules, which at starting are spread evenly along the bottom of the cylinder, and to shower them down through the water. By means of the sluice-cock L, the flow of water may be regulated to the speed required to give the duration of contact with the iron found necessary for efficient purification under the particular circumstances.

Minute quantity of iron dissolved.

From experiments made previously to the adoption of Anderson's Revolving Purifier for the purification of the Antwerp water supply, it was found that the **rate at which iron was dissolved** by ordinary river water was only $\frac{1}{10}$th grain per gallon, Bischof's spongy iron being the form of iron experimented on. In actual practice at Antwerp, cast-iron borings have been mostly used, spongy iron being less suitable for the purpose, on account of the irregularities of its surfaces, and its much greater first cost. Cast-iron borings have, however, the disadvantage of being very friable and easily knocked to pieces, so that in addition to the waste of iron due to chemical action, there is a still greater loss from the carrying away of the pulverised metal by the flow of water.

Various forms in which the iron may be used.

The most convenient and economical forms of iron for use in revolving purifiers are "granulated iron," cast-iron balls, and small "burrs" from punching machines. As far as present experience shows, the last three forms lose about the same weight per gallon of water purified. This loss may be taken at an average of $\frac{1}{5}$ grain per gallon, as against $\frac{3}{5}$ grain when cast-iron borings are used. Cast-iron borings may, however, frequently be had at $\frac{1}{3}$ of the cost of either of the less friable forms of the metal, so that the material so used should be the one most easily available in the particular locality. Should either of the harder forms be chosen, care must be taken that their particles are not so large and heavy as to injure the cylinder. A good rule is that all the iron shall pass through a sieve of $\frac{3}{8}$-inch mesh, when required for use in sizes of apparatus up to 6 inches, and through a $\frac{1}{2}$-inch mesh for larger sizes.

Chemical action.

On issuing from the purifier the water or sewage under treatment is charged with a soluble ferrous salt which immediately begins to change into the insoluble ferric oxide by the process of oxidation due to its contact with the air. The rapidity with which this precipitate forms varies considerably, according to the nature of the liquid being purified. With most ordinary river waters the aëration obtained by running along an open trough or channel of moderate length is sufficient, the water being discharged from the trough on to a shallow sand filter, by

Aëration.

which the precipitated oxide may be rapidly strained out, leaving the water fit for consumption. Where more energetic aëration is required, air may be blown into the water on its leaving the purifier by a rotary blower, or, where convenient, the water may be allowed to fall down a cascade before filtration through sand.

Subsidence.

Filtration.

For economical working it is advantageous to send the purified liquid into a settling tank, in which the precipitated iron will remain, the water being decanted from the surface after a few hours' subsidence, and then filtered rapidly through sand or other mechanical filtering medium. By this means the filter receives only the very finest particles of the precipitate, and may run for a long period without cleaning. The time required for the complete conversion of the ferrous salt into its insoluble form is from four to six hours. Rotary blowers are supplied with the apparatus when required, and in all cases the Company will advise as to the most efficient and economical arrangement for removing the iron precipitate. **No trace of iron remains after filtration.**

In cases where it is not required to utilise the purified water or sewage, filtration may be dispensed with, the purified liquid being sent into a river or lake, either with or without previous settlement in a reservoir or tank. The iron precipitate is of itself of a purifying nature, and would often beneficially affect the river or lake into which it flowed, the ferric oxide settling down to the bottom, and clarifying the water in its descent.

CHAPTER II.

THE ADVANTAGES OF THE REVOLVING PURIFIER COMPARED WITH OTHER METHODS OF PURIFICATION AND FILTRATION.

1. Its great simplicity and the rapidity of its action.

Automatic renewal of active surfaces of iron.

The iron being in a constant state of agitation, no choking or caking together of the purifying medium is possible. The particles of the finely divided metal are kept rubbing against one another, and new surfaces are brought into contact with the water, which in its flow carries out of the cylinder the iron which has been dissolved by chemical action with the impurities contained in the water. Owing to the completeness of the contact between the iron and the water and the large surface of metal exposed, purification is effected in a space of time of 3½ to 5 minutes for moderately bad water, and in 5 to 15 minutes for sewage effluents.

The necessity for this.

We have already pointed out (p. 3) that the only practical experiment yet made on the large scale of *filtering* impure water through iron, though promising well for several months, ended in failure. Were further proof needed of the **impossibility of using a chemically acting material in the form of a filter,** a visit to the Antwerp Waterworks would dispel the delusion. Started to work in 1881, the spongy iron filters had become unworkable early in 1884, during which year some 2000 tons of the mixture of iron and gravel forming the filter-beds had to be removed, the cost of the patent material thus sacrificed having been £8000. An immense heap of this mixture still unutilised bears silent witness to the failure of the attempt to make filter-beds which would at the same time remove the dissolved impurities of the water and remain permeable. It is astonishing, in face of such experience as the Antwerp Waterworks Company had to pay for so dearly, that purifying materials are constantly being advertised for use on a large scale, and are boldly stated by their inventors to be capable of permanent application *in the form of filters* for the treatment of water or even sewage.

Gradual deterioration of filters.

Again, it is evident that any purifying material spread out in a filter is constantly reducing the area of its active service by the formation of the compounds which it makes in removing the dissolved impurities of the liquid it is filtering. The degree of purification effected must therefore constantly decrease until steps are taken to remove the products of the purifying action, and to revivify the purifying material. This has always been one of the greatest difficulties encountered when endeavouring to purify water or sewage on any scale of greater magnitude than that of a laboratory experiment, or of a domestic filter. The Revolving Purifier entirely overcomes this difficulty by the constant rubbing together of the particles of the purifying material, and the carrying away by the liquid itself of what we may generally term the products of the purification.

2. The great speed of filtration through sand permissible after treatment by iron.

Rapid straining out of the iron precipitate.

On leaving the Revolving Purifier the dissolved iron is precipitated by aëration in the form of insoluble ferric oxide, which is removed by a rapid straining of the water through a shallow layer of sand. To obtain even a moderately bright water it is generally necessary to limit the rate of filtration through sand filters of the ordinary type to a rate not exceeding 2 gallons per square foot of filter surface per hour, or 48 gallons per 24 hours. Waters that were originally highly charged with colouring matters may, after passing through a Revolving Purifier, be filtered through 18 inches of sand at a rate of 80 to 150 gallons per square foot per 24 hours, and at this speed rendered perfectly colourless and as bright as deep well waters.

3. The smallness of space occupied by the purifying plant.

Smallness of plant.

At Antwerp, in Belgium, where this system of purification has now been at work day and night for 4½ years, the apparatus for treating 3½ million gallons per day are contained in a building measuring 40 feet by 31 feet. Also one single Revolving Purifier has been now two years at work at Dordrecht, in Holland, and purifying at a guaranteed rate of 880 gallons per minute, the whole plant including inlet and outlet tanks and a turbine for driving the purifier being enclosed in a building 45 feet long and 20 feet wide.

4. Lowness of cost.

Capital outlay.

For large volumes of water it may be estimated that the first cost of the necessary purifying plant for this system is about £1000 per million gallons of water purified daily. On account of the increased rate of filtration through sand, and the consequent reduction of area of sand filters rendered possible by a preliminary purification in a Patent Revolving Purifier, it is found that **less capital outlay is required per million gallons output for establishing purifying plant and sand filters together than for making the sand filters alone,** the purified water being at the same time better in appearance, and far superior in quality to the same water simply filtered (*vide* Dordrecht Report, p. 27). The working cost of this process is also so extremely low as to render it without a rival for the treatment of large volumes of water. The result of three years' working, estimated on a daily consumption of a little over 1½ million gallons, the purification of the very bad peaty water used for the supply of Antwerp costs four shillings per million gallons. Of this sum, one shilling and fivepence is for iron, and the remainder for driving power and supervision. The latter items are of course enormously reduced in dealing with very large volumes of water. The cost of sand filtration used in conjunction with Revolving Purifiers also varies very greatly, according to the extent and arrangement of the means adopted for precipitating the ferric oxide before the water reaches the sand; the expense involved is solely that of removing the thin film of deposit from the surface of the sand. With subsiding reservoirs of sufficient area to allow of six hours' settlement before filtration, the cost of the latter may be reduced to a figure far below that of ordinary filter cleaning.

Low working cost.

5. The great Chemical and Physiological improvement effected in the water purified.

Analysts consulted.

The results of some 200 analyses, made by Sir Frederick Abel, Drs. Frankland and Tidy, and by Mr. G. H. Ogston, F.C.S., in England; by Professor Marié Davy (chemist to the city of Paris), by Professors Van Ermengem, Blas, Swarts, and Kemna, and Drs. Angenot, Jorissen, Van Melckebeke, Van de Velde, Van de Ven, Giltay, Dubois, and many other eminent chemists on the Continent, show that **metallic iron applied in the Revolving Purifier,**

(*a*) **Removes all colour from water, whether caused by the presence of finely divided suspended matter such as clay or of dissolved substances such as are generally derived from contact with peaty soils or decayed vegetable matter.**

Removes colour.

(*b*) **Reduces organic matter—as measured by the quantity of oxygen required for its oxidation—from 45 to 90 per cent., the reduction being greatest when the organic matter is of animal origin.**

Reduces organic matter and

(*c*) **Reduces organic matter—as represented by the more important albumenoid ammonia—from 75 to 90 per cent.**

Albumenoid ammonia.

(*d*) **Entirely removes free ammonia and nitrous acid, and reduces nitric acid to the faintest trace.**

Removes free ammonia.

(*e*) **Applied for the purification of water supply on the large scale, the Revolving Purifier system effects the complete sterilisation of the impure water by entirely removing all micro-organisms.** This extraordinary fact is conclusively proved by the experiments made at Antwerp by Professor Van Ermengem, on samples drawn at frequent intervals from the delivery pipes of the sand filters when supplying over 2 million gallons per day; the **100,000 microbe colonies contained in a cubic centimetre** of the Nethe water **are reduced to an average of 5 colonies,** which, considering the great difficulty of avoiding all contact with the air in these delicate tests, **is equivalent to a complete destruction of the micro-organisms.** (See p. 25).

Entirely destroys microbes.

6. By means of the Revolving Purifier **the waters of rivers, streams, and lakes,** whose impurity has hitherto rendered their utilisation impossible, **are rendered available as sources of potable supply.** The investigations of the numerous scientific authorities whose reports will be found below, prove incontestably that 3½ minutes' contact with metallic iron in the Patent Revolving Purifier followed by a rapid sand filtration **converts these convenient sources of supply into a potable water, which is equal to the purest and most healthy spring water.**

River and lake water converted into pure potable water.

CHAPTER III.

VARIOUS METHODS OF APPLYING THE PATENT REVOLVING PURIFIER.

The Antwerp Waterworks.

Plate II. represents a battery of five Revolving Purifiers, as erected at the pumping station of the **Antwerp Waterworks** at Waelhem, near Malines, Belgium. This group of apparatus is contained in a building 43 feet long by 31 feet wide, and is capable of purifying in the aggregate up to nearly four million gallons of river water per twenty-four hours. In this case the purifiers are driven, either together or separately, by belts off pulleys on a horizontal shafting carried by brackets on the wall of the house. At each end of the shafting is a 6-horse-power wall steam-engine—either engine being powerful enough to drive all five purifiers and an air-blower, the other being kept as a stand-by. The purified water is delivered into an outlet tank common to all, and which communicates with the sand filters by means of a long open trough, which forms a continuation of the outlet tank inside the house.

General plan.

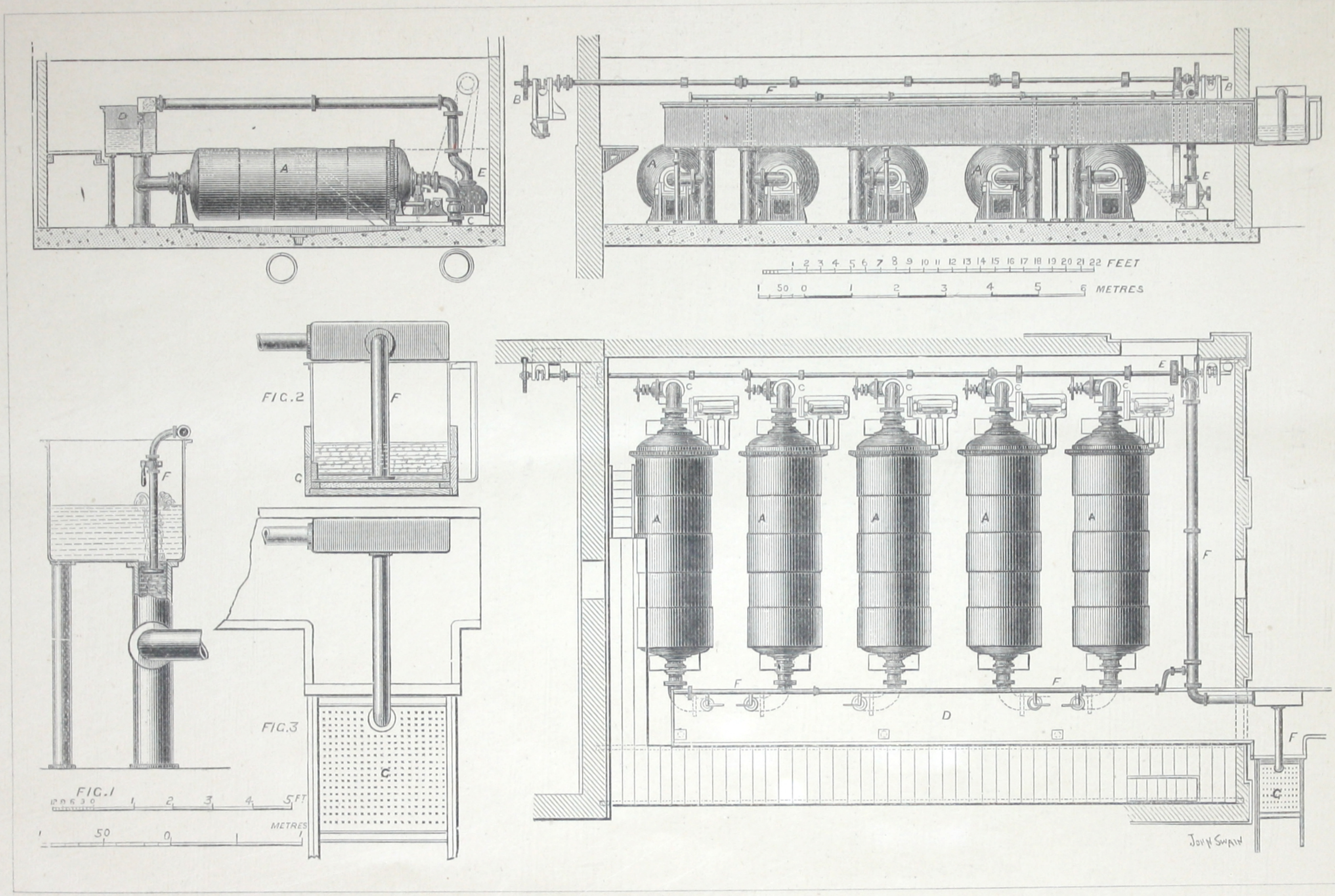
The River Nethe being a tidal river, the day's supply for Antwerp is taken into a storage reservoir during the ebb tide. From this reservoir the river water is raised by two of Airy's patent screw pumps into two small tanks which serve as head tanks to the battery of purifiers, the screw pumps serving admirably as water meters, measuring with great accuracy the amount of water supplied per minute to the Revolving Purifiers, and consequently enabling the regulation of the duration of contact between the iron and the water to be effected with great simplicity. On leaving the purifiers, all of which deliver into the same outlet tank, the water flows along an open channel to a cascade, falling into one of two settling ponds, where the greater part of the precipitated iron remains, together with the whole of the matter originally in suspension in the water.

To further aid the oxidation of the ferrous salts recourse is sometimes had to artificial aëration, though this is unnecessary with fairly good river water.

Artificial aëration.

The arrangement adopted for artificial aëration at the Antwerp Waterworks is represented on Plate II., Fig. 1. A 3-inch iron pipe runs along the whole length of the outlet tank, which is common to all the purifiers. A 1½-inch branch, provided with a plug cock, descends from this pipe over each of the vertical outlets, into which it enters to a depth of some 18 inches below the mean water level in the tank. The lower end of each branch terminates in a circular plate 5 inches in diameter, leaving an annular space 2½ inches in width, through which the outflowing water and air pass together into the tank. A second mechanical aëration is provided by means of a 6-inch pipe, Figs. 2 and 3, which conveys air from the blower under a series of sheets of finely perforated zinc, arranged to form a false bottom to the first portion of the open trough along which the purified water flows on to the sand filters. Through this false bottom countless small bubbles of air rise and mix with the water. The water then flows along the open channel to the settling ponds, whence it is drawn, after settlement, through a floating suction pipe and sent on to the sand filters.

PLATE II.

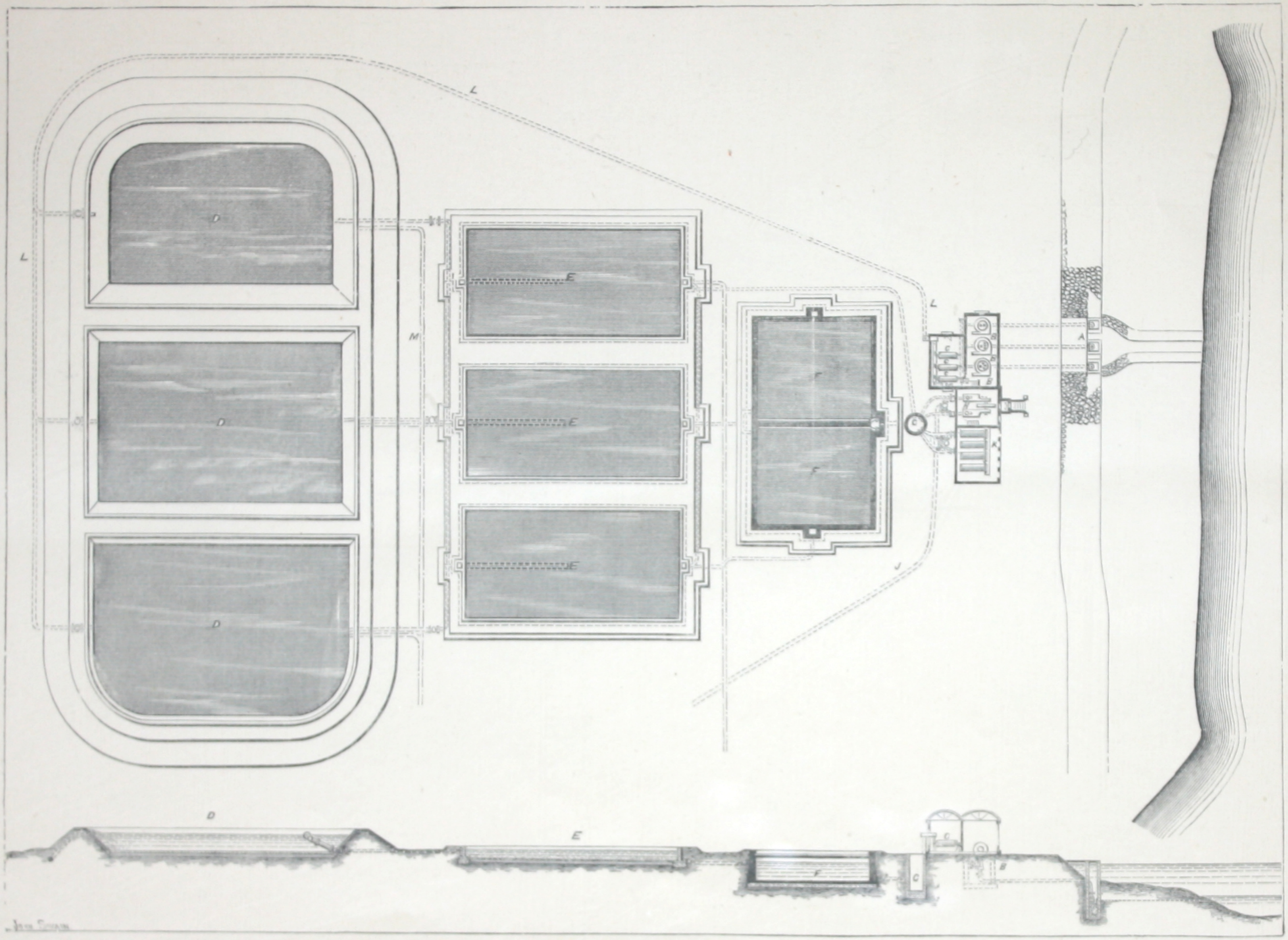

A
B
C
D
E
F
G
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 FEET
1 50 0 1 2 3 4 5 6 METRES
FIG.1
FIG.2
FIG.3
12 10 5 3 0 1 2 3 4 5 FT
1 50 0 1 METRES
JOHN SWAIN

ARRANGEMENT OF REVOLVING PURIFIERS AT THE ANTWERP WATERWORKS.

Plate III. shows a typical arrangement of Revolving Purifiers, settling reservoirs, and filters, similar to that now being constructed for purifying the **waters of the River Jumna, in India.** By the adoption of the Revolving Purifier the municipality of Agra is enabled to utilise this water for the supply of their town. In this arrangement the water is raised from the river by three-throw pumps, and sent through three 10-inch Revolving Purifiers to the settling tanks. These, which are three in number, have a capacity of 1,600,000 gallons each, with a working depth of 7½ feet. The purified water drawn from the surface of these tanks, after each has in turn been allowed a few hours' undisturbed settlement, is filtered through three filters, which have been calculated for a speed of 30 gallons per square foot to begin with. This leaves a very large margin for the future growth of the supply, as with the ample settling tanks provided the speed of filtration will certainly be capable of increase up to 90 gallons per square foot. The plan schemed for Agra will serve as a type for most other towns on the great rivers of India; the adoption of the Revolving Purifier system is already under consideration for three other important cities on the Jumna, and has been adopted for Baroda. The plant for Agra will be capable of purifying 2,000,000 gallons per 24 hours.

A, Intake Wells. B B B, Three-throw Pumps. C C C, 10-*inch Revolving Purifiers. D D D, Settling Tanks. E E E, Sand Filters. F F, Pure Water Reservoir. G, Main Pumps Suction Well. H, Main Engines and Pumps. I, Rising Main. K, Boilers. L, Delivery from Revolving Purifiers to Settling Tcnks.*

PLATE III.

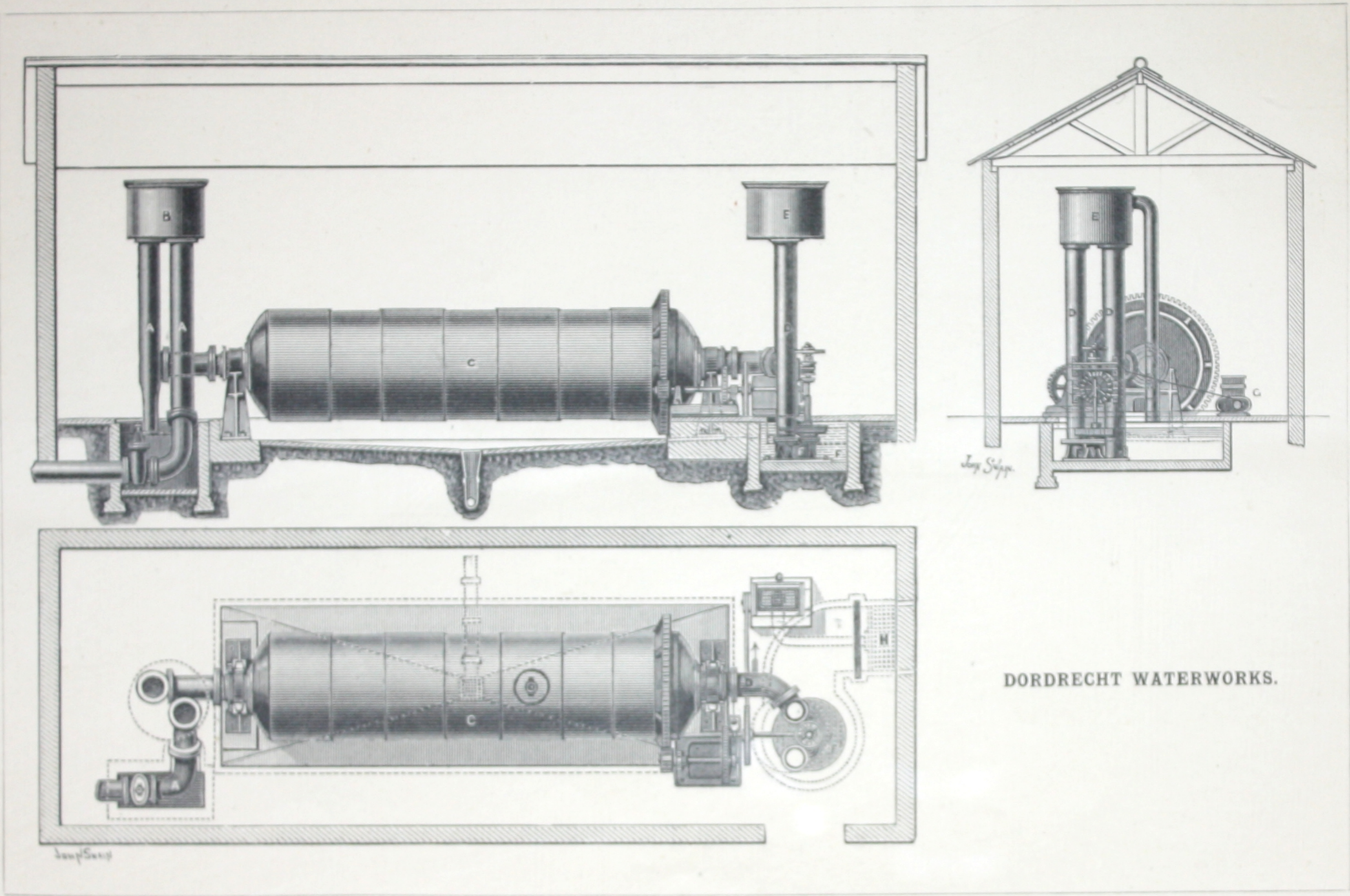


ARRANGEMENT FOR THE PURIFICATION OF THE WATER OF THE RIVER JUMNA, FOR THE SUPPLY OF THE CITY OF AGRA.

Plate IV. shows a most convenient arrangement as adopted at **Dordrecht and Gouda, in Holland.** In this arrangement the small driving power necessary for the rotation of the apparatus is supplied by a reaction wheel placed at the outlet end of the Revolving Purifier. The river water is pumped direct into a small circular inlet tank, whence it flows through the cylinder to the outlet tank, the delivery pipe from which supplies the reaction wheel which turns the cylinder through a train of gearing, at the same time driving a Roots blower, which gives the artificial aëration required with some waters. This arrangement has the advantage of being automatic, the purifier commencing to revolve as soon as the river water is pumped through it.

A, Inlet Pipes. B, Inlet Tank. C, 14-*inch Rveolving Purifier. D, Outlet Pipe. E, Outlet Tank. F, Reaction Wheel. G,* 6-*inch Roots Blower. H, Aërating Trough.*

PLATE IV.

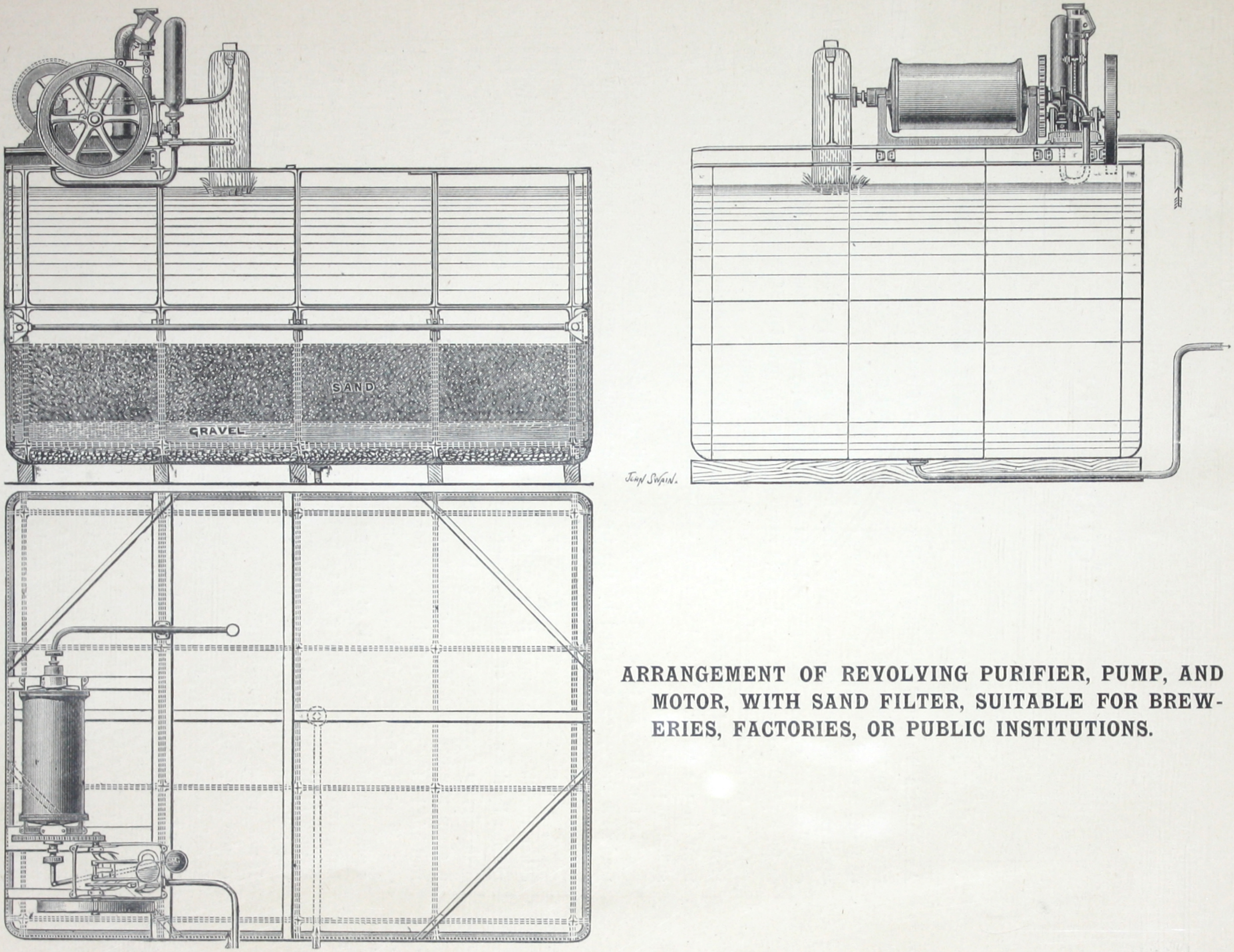


DORDRECHT WATERWORKS.

PLAN AND ELEVATION OF REVOLVING PURIFIER, WITH TURBINE AND BLOWER.

Plate V. shows a 1½-inch Revolving Purifier adapted for the **supply of a factory or other establishment** where large quantities of pure drinkable water are required. An arrangement similar to that illustrated is in constant operation at the ironworks of the Société anonyme des Anciens Établissements Cail, at Paris, where the water, drawn from the Seine at a point below the city, is purified and supplied for drinking and domestic purposes to some thirty families connected with the staff of the works. In this case the purifier is fixed on the top of a reservoir, placed at the highest point of the building, and serving also as a sand filter. Movement is given to the cylinder by a belt off the main shafting of one of the machinery shops, no special motor or pump being necessary in this instance. Where no convenient motive power already exists, the very compact arrangement, combining Revolving Purifier, pump, motor, and sand filter, as illustrated, will be found very suitable. Plant of this kind could be designed for purifying and filtering up to 15,000 gallons per day.

PLATE V.



ARRANGEMENT OF REVOLVING PURIFIER, PUMP, AND MOTOR, WITH SAND FILTER, SUITABLE FOR BREWERIES, FACTORIES, OR PUBLIC INSTITUTIONS.

CHAPTER IV.

DIMENSIONS AND DELIVERIES OF PATENT REVOLVING PURIFIERS.

Denomination of apparatus.

ANDERSON'S Patent Revolving Purifier is made in fourteen sizes, which are denominated according to the diameter of their respective inlet and outlet pipes. In determining the size of purifier required for a given number of gallons of water per day, calculations must be based upon the duration of contact with the iron found necessary by previous experiment for the most complete purification of the particular water. For ordinary river water capable of being rendered fit for a potable supply, it may be said generally that this duration of contact must never be less than 3½ minutes, and need be seldom more than 5 minutes. Excessive contact causes more iron to be dissolved than can easily be precipitated, without producing a proportional improvement in the water. With less than 3½ minutes' contact it is difficult to ensure regular or sufficient purification.

Duration of contact.

In the following table the capacity of the purifier is given in gallons, allowance having been made for the space occupied by the iron. The maximum quantities of water that can be purified per 24 hours, with contact between iron and water of 3½ and 5 minutes, are also given.

To determine the delivery of a purifier per 24 hours when allowing any other duration of contact, it is sufficient to divide the number of gallons contained in the purifier by the number of minutes' contact required, and to multiply the result by 1440. Or, inversely, to determine the size of purifier required for a given number of gallons per day with a given number of minutes' contact, divide the total 24 hours' requirements by 1440, and multiply by the number of minutes of contact.

Large delivery of Purifiers.

It will be noticed what large volumes of water may be purified by a single apparatus, a 14-inch purifier being capable of treating over 1¼ million gallons per day with 3½ minutes' contact, and occupying a space of 34 feet by 10 feet only. At the Dordrecht Waterworks a purifier of this size has been erected, and is at work for several hours daily, at a delivery of 880 gallons per minute, the duration of contact with the iron being a fraction under 4 minutes. It not unfrequently happens that the water to be purified varies in quality at different seasons of the year, and requires corresponding variations in the duration of its contact with the iron. In this case, of course, the purifier selected must be of sufficient size to give the longest contact likely to be necessary under the most unfavourable circumstances.

Rapidity of sand filtration.

The fifth column of the table gives the **area of sand filters required** to correspond with a purifier when working with 3½ minutes' contact, and calculated for a rate of 80 gallons of water filtered per square foot per 24 hours. Should the purifier be given a longer contact, the rate of filtration will be proportionately reduced. With very bad waters, however, unless arrangements are made for the subsidence of the heaviest portion of the precipitate before filtration, it might be necessary in some cases not to reduce the areas of sand surface below the figures given, even when the purifier is delivering the smaller quantity with the increased duration of contact. Where an efficient subsidising reservoir is placed between the purifier and the sand filter, the rate of filtration may, in many cases, be increased beyond 80 gallons, and the area of the sand filters reduced accordingly.

Periodical addition of iron.

The sixth column shows the **weights of the initial charges of iron** introduced into each purifier when first set to work. **It is not found necessary ever to remove and renew the whole of the iron** with which the apparatus is charged. It is sufficient to maintain the weight of the initial charge by the periodical addition of so much of the metal as is necessary to compensate for the loss due to the chemical action and the mechanical washing away of the particles of iron by the water. The frequency of the periods at which to add fresh iron will vary according to the quantity of water passed through the apparatus and the rate of waste. Generally speaking, the iron should be brought up to its original weight once a week.

Driving power.

The seventh column of the table gives the **amount of driving power** required for each purifier in foot-lbs. per minute, from which the horse-power of the motor required can be calculated.

Space occupied.

The last column shows the **floor space** covered by each complete apparatus.

Duplication.

In designing an arrangement of revolving purifiers for large volumes of water or sewage, where the machinery will be constantly at work, or nearly so, it is advisable to allow for duplicating the plant by selecting two apparatus of smaller size, each capable of treating say five-eighths of the day's supply, rather than a single purifier to do the whole work alone. Where pumping is intermittent, or where it is convenient to reduce its amount during some part of the twenty-four hours, this duplication is particularly convenient, one apparatus being temporarily stopped.

DIMENSIONS AND DELIVERIES OF PATENT REVOLVING PURIFIERS.

Size of Inlet Pipe.	Capacity of Cylinder.	Delivery in Gallons per 24 Hours.		Area of Sand Filters required at 80 Gallons per Square Foot per 24 Hours.	Weight of Initial Charge of Iron.	Driving Power in Foot-pounds per Minute.	Floor Space occupied by Complete Apparatus.
		3½ Minutes' Contact.	5 Minutes' Contact.				
inches.	gallons.			square feet.	lbs.		ft. in. ft. in.
1	15	6,170	4,320	80	28	690	5 6 × 1 8
1½	31	12,700	8,890	160	60	880	7 0 × 2 0
2	61	25,180	17,620	320	97	1,380	8 0 × 3 5
2½	96	39,490	27,640	500	153	1,800	10 0 × 3 5
3	138	56,770	39,740	720	224	2,500	10 0 × 5 4
4	246	101,210	70,840	1,270	392	4,130	11 0 × 5 9
5	381	156,750	109,720	1,970	616	5,630	14 6 × 5 9
6	576	236,980	165,880	2,965	896	5,880	15 6 × 7 6
7	771	317,200	222,040	3,965	1,187	7,440	19 0 × 7 6
8	978	402,370	281,660	5,040	1,568	9,880	19 0 × 8 0
9	1,287	529,500	370,650	6,620	1,971	12,000	22 0 × 8 0
10	1,689	694,900	486,430	8,690	2,464	15,000	23 6 × 8 0
12	2,319	954,100	667,870	11,930	3,584	20,630	30 0 × 8 6
14	3,126	1,286,120	900,280	16,090	4,704	28,500	34 0 × 10 0

REPORTS AND ANALYSES.

I. ANTWERP WATERWORKS.

Water from the River Nethe.

It was at the Pumping Station of the Antwerp Waterworks that the Patent Revolving Purifier came into practical existence in the year 1885, and it is there that the process has gone through the successive steps which have led to its present perfection. It will therefore be interesting to quote reports on the working of the Revolving Purifier at Antwerp since its commencement.

The water supplied to the city in 1885 was considered to be of inferior quality, and complaints were made of its taste and smell. The authorities therefore appointed a Commission, consisting of five well-known Belgian chemists, to report upon the water supply. These gentlemen published, in November 1885, a very exhaustive Report, which concludes as follows :—

1885.

"It results, from the work of this Commission, that the water supplied by the Waterworks Company during the months of August and the beginning of September 1885, has left something to be desired from the chemical point of view, and its 'organoleptic' properties (taste and smell) rendered it unsuitable for most domestic uses. The Commission must, therefore, declare the complaints of the public both well founded and legitimate; but it cannot share in the exaggerated fears which have been expressed. Nothing, in fact, allows it to be considered that this water has ever been insalubrious, or as having placed the public health in danger.

"The cause of this temporary state of things has been a consumption suddenly increased far beyond the largest expectations, and allowing the Company no other alternatives than those of either seeing its installations dried up or of effecting a hasty and insufficient filtration. At the same time, a raw material, more concentrated by the prolonged drought, rendered purification more difficult. **The doubts which might have been conceived of the efficiency of the process** (of purification) **fall to the ground before the researches of the Commission, which confirm those of the English scientists. It will be sufficient for the Waterworks Company to increase its installations, and to modify, in a few points, its operations in the way indicated above, to allow of its ensuring always what it now is supplying, an irreproachable drinking water."**

The Report also says, after describing the former system of "spongy iron" filters :—

"The Commission recognises that the Anderson Purifiers constitute a great step in advance over the filtering basins. Well handled, they appear of at least equal efficiency, they are much more economical; they are more scientific in character, in that they allow of proportioning the duration of contact to the degree of impurity of the water."

The Commission also made microbiological examination of the water, with a view to determine the influence of the process in the destruction of bacterial life. Samples of water drawn from a tap in the city were submitted to a series of tests, from which the following conclusions were drawn :—

"The water of the supply, while not being exempt from microbes, contains only a very small quantity of them, and far less than one generally finds in the majority of natural waters."

Acting on the recommendations of the Commission, the Waterworks Company added two more 10-inch Purifiers, and made a few modifications in the working of the process, with excellent results, as is shown by the following extracts translated from a report made to the 1887. Company in May 1887 by Professor Blas, of the University of Louvain, and Dr. Jorissen, of the University of Liége, who were invited to make a joint analysis of (1) the river water taken from the subsiding reservoirs before purification ; (2) the purified water as it left the purifiers at the pumping station ; (3) a mixture of samples drawn from several of the public standposts of the city. On these samples the analysts report as follows :—

> "Water No. 1 is thick, coloured ; it exhales a disagreeable smell and leaves an abundant brown deposit. Taking these properties in conjunction with the results of chemical analysis, we conclude that this water is not potable.
>
> "Water No. 2 is limpid, colourless, without either disagreeable taste or smell ; it does not deposit, and is not spoiled by keeping. Taking these qualities in conjunction with the results of the chemical analysis, we consider this water as potable and of good quality.
>
> "As to sample No. 3, it is identically like sample No. 2.
>
> "In comparing the results furnished by the analysis of the samples 1, 2, and 3, it is seen that the process of purification applied by the Waterworks Company, whose installation we have visited in detail, has the effect of depriving the water of the Nethe of the matter it holds in suspension, of causing the complete disappearance of the ammonia and nitrous acid, and of reducing by 50 per cent. the proportion of organic matter found in this water before purification. . . . . **We consequently conclude that the process of purification applied at Waelhem at the time of our visit produced good results,** and that the water of the supply of the city of Antwerp, analysed by us, may be considered to be a **potable water of good quality.**"

The progressive improvements obtained by the extension of the means of aëration, and the addition of settling ponds in which the purified water is received before filtration, enabled the Water Company to say at last that, from the impure source at its disposal, it was supplying to the city water of the most remarkable purity. In order to satisfy themselves and the public on this point, the Company nominated four eminent chemists to make weekly analyses of the water, and to give a quarterly report on the results of these analyses. The translation of the Quarterly Reports published up to the present is as follows :—

1889.

"FIRST QUARTERLY REPORT, 1889.

"ANTWERP, 8*th May*, 1889.

"The undersigned : Ch. Blas, Professor at the University of Louvain ; A. Jorissen, Professor at the University of Liége ; Th. Swarts, Professor at the University of Ghent ; E. Van Ermengem, Professor at the University of Ghent ; have separately carried out a series of weekly analyses of water of the Antwerp water supply during the first quarter of the year 1889.

"The following results have been obtained :—

Residue on evaporation	0·140 gr. to 0·193 gr. to the litre.
Chlorine	0·015 gr. to 0·016 gr. to the litre.
Organic matter (Kübel's method)	0·027 gr. to 0·053 gr. to the litre.
Ammonia (direct process)	None.
Free Ammonia (Wanklyn's process)	Trace.
Albumenoid Ammonia (Wanklyn's process)	0·00009 gr. to 0·0001 gr. to the litre.
Sulphuric Oxide	0·003 gr. to 0·020 gr. to the litre.
Nitric Acid	0·000 gr. to 0·003 gr. to the litre.
Nitrous Acid	None.
Total Hardness	7°·5 to 11°.
Taste and Smell	Normal.
Flavour	That of very soft water.

Bacteria, number of colonies per cubic centimetre after 4 days, from 31 to 140, no pathogenic micro-organism or any of a suspicious kind.

"The results obtained by chemical analysis prove this water to be of irreproachable purity and of excellent quality, both for drinking and industrial purposes.

"The bacteriological analysis allows it to be affirmed that the water is perfect from a hygenic point of view, containing hardly more microbes than spring water in general, and no microbe of a dangerous or suspicious nature.

"(Signed) CH. BLAS. A. JORISSEN.
TH. SWARTS. E. VAN ERMENGEM."

"SECOND QUARTERLY REPORT, 1889.

"ANTWERP, 10*th July*, 1889.

"The undersigned, having separately carried out weekly analyses of the water of the Antwerp supply, during the second quarter of the current year, state that this water has maintained its good quality mentioned in their first Quarterly Report, both as regards its organoleptic character (i. e. colour, taste, or smell) and its chemical and microbiological character. When taken immediately on leaving the filters working in their normal way, and before any ulterior contact with the air, **the water contains from four to six microbes per cubic centimetre, a fact which places it on a par with the purest and most healthy spring water.**

"These results are the more remarkable as they have been obtained during the period of summer heat, when the water of the river was undergoing a marked change for the worse. *They demonstrate the efficiency of the system of purification* applied at Waelhem.

"(Signed) SWARTS. VAN ERMENGEM.
JORISSEN. C. BLAS."

II. AGRA WATERWORKS.

River Jumna.

The following report has been made to the authorities by Mr. A. J. Hughes, M. Inst. C.E., Supervising Engineer, Municipal Works, N.W.P., and Oudh, India, on the experiments made at Agra for the purification of the waters of the River Jumna :—

"Anderson's 'Revolver,' tried with a rate of 33 to 37 gallons, reduced the albumenoid ammonia from 0·33 to 0·12 ; the reduction of organic matter by sand filtration, at a speed of 24 gallons per square foot, was 57 per cent., and by Anderson's process with a speed of 35 gallons, the reduction was 64 per cent. The efficiency of the 'Revolver,' as compared with sand filtration, was as 64 to 57, or 12 per cent. better results, at 50 per cent. higher speed of filtration."

These figures refer to a small experiment made with a 3-inch Revolving Purifier and a new sand filter. From universal experience with the Revolving Purifier it may be confidently stated that, on a large scale, the superiority of the Revolving Purifier process over the ordinary system of sand filtration will be very much more strongly marked. As a result of the experiments, three 10-inch Revolving Purifiers have been ordered for Agra, and will shortly be erected.

III. GOUDA WATERWORKS.

River Ijsel.

A 9-inch Revolving Purifier was erected at Gouda, in Holland, during the summer of 1886, experiments having shown that a few minutes' contact with metallic iron in the Revolving Purifier entirely removed the very strong yellow which is characteristic of the peaty waters of the River Ijsel, as it is of most of the Dutch rivers. The following report was received from the manager of the works in October, 1887 :—

"For the last three weeks we have got the bad water at our works and are using the Purifier. I am glad to tell you it is acting very well, better than last year. The town water is at this moment without colour, clear, and the effect of the purification with sand filtration, and without the solution of alumina, is to produce 55 per cent. improvement (in the organic matter)."

IV. THE DORDRECHT WATERWORKS.

River Merwede.

The following extracts, translated from the official Report made in September 1887 by Mr. François, Engineer to the town of Dordrecht, in Holland, and entitled 'Report on the arrangement and working of Anderson's Revolving Purifiers on the premises of the High-Pressure Water Service of the Commune of Dordrecht,' shows the success which has attended the application of the iron process in this case. The saving of capital outlay effected by the addition of a purifier to existing works is strikingly illustrated, and the necessity is shown for mechanical aëration experienced with a certain class of waters :—

"The unexpectedly great popularity enjoyed by the High-Pressure Water Service in this place very soon after its establishment, caused the water consumption to be so great that the existing settling ponds and filters were considered too small for the complete settling and filtration of the necessary quantity of water. General estimates of extensions gave the expense involved, and as it was a question whether, with an **increase of capital to the extent of about 150,000 fl.**, the low tariff here in force would be sufficient to yield the interest on it, the question arose whether such an extension were absolutely necessary, and whether the same object could not be attained in some cheaper way.

"The weekly examinations of the water as to its organic contents had proved that a speed of filtration of 2·1 cubic metres to 1 square metre of surface could not be exceeded without its having a prejudicial influence.

"On most occasions the river water was of such quality that the quantity of organic matter in the filtered water remained below the maximum that had been assumed as a limit not to be exceeded in good drinking water, but sometimes the contrary was observed, and provision was thus distinctly necessary. In foreign periodicals for some time past attention had been drawn to the oxidising effect of iron on the organic ingredients of water. Experiments had shown that when one brought iron into intimate contact with foul water, the water took up a great quantity of iron, which in its turn was kept back on subsequent sand filtration ; at the same time on examination it appeared that the organic matter in the filtered water was very considerably diminished, the ammonia wholly removed, and the noxious microbes annihilated." . . . .

The Report proceeds to state how the satisfactory experience gained at Antwerp, and the offer of the inventor's firm to guarantee the success of the iron process at Dordrecht, induced his municipality to conclude a contract with Messrs. R. S. Stokvis and Sons, of Rotterdam, acting on behalf of Messrs. Easton and Anderson, the manufacturers of the Revolving Purifier :—

"According to this contract the township undertook the construction at its own expense of a proper foundation for the apparatus and of a building for its protection. Messrs. R. S. Stokvis and Sons undertook the delivery and erection of the Revolving Purifier, with all accessories, guaranteed its good working for six months from the date of completion, and were to receive within fourteen days after the expiration of the term of maintenance a **sum of 16,700 fl.**, and interest at 5 per cent. per annum on that amount for any delay in acceptance beyond three months after completion.

"It was further stipulated that by 'good working' should be understood:

"*a.* **The removal of the yellow colour** which the river water at Dordrecht exhibits at certain times.

"*b.* **The increase in the speed of filtration** through the existing sand filters to 4000 litres of water per square metre of sand surface in twenty-four hours.

"*c.* **A chemical improvement** in the quality of the river water proportionally as great as that in the sample tested by Mr. G. H. Ogston, chemist, at London, of which the official analysis dated 24th November, 1885, was appended to the contract."

The Report next describes the apparatus erected, of which an illustration is given in Plate IV., and continues :—

"As it was inconvenient to apply the existing steam-engine for the purpose of turning the purifier, and as a special steam-engine or gas-motor would have caused too heavy a charge on the working, the pressure of the water leaving the purifier has been utilised for driving a turbine, which in its turn actuates the whole apparatus. In this way the motive power for the purifier costs nothing. . . . . On leaving the purifier the water is much charged with iron, and this iron must be again thrown down by the influence of the air. The better the supply of air is, the better is the object attained. For this reason the water which leaves the purifier flows through a broad open iron gutter of considerable length, from which it is precipitated on to the filters. In this gutter there are barriers fixed, behind which the suspended particles of iron are retained, and which help at the same time to expose continually new portions of the water to the air through the eddying motion they set up in the water. Also, with a view of getting as intimate contact as possible between the water particles and the air, the water then flows over broad steps covered with coke on to the filter-bed.

"In ordinary conditions of the river water this arrangement is sufficiently effective, but with the so-called 'thick' river water it appeared that in this way the water could not be got quite colourless. This was ascribed to an insufficient oxidation of the iron, and it was resolved to apply still more air to the water by artificial means. For that purpose a Blower (a sort of air-forcing apparatus) was fixed and driven by the Revolving Purifier. This apparatus forces air into a zinc box, placed in the open gutter, where it leaves the purifier house ; the cover of this box is provided with a number of small holes, by which the air finds its way out and then bubbles with great force and velocity through the water flowing over it. By this arrangement **even unusually thick river water was proved to become quite colourless after filtration.**

"Repeated experiments and examinations had shown that the water fulfilled the conditions specified under (*b*) and (*c*), but the colourlessness had for a long time been unsatisfactory. We had, however, the good fortune, soon after the application of the last improvements, in the beginning of June last, to get river water thicker than it ever is in winter ; and then was proved the efficiency of the arrangement, as it was at that time. Notwithstanding that it had little time for previous settlement, and that it was filtered for several days and nights without intermission at the guaranteed speed, the water remained clear, a fact of which every water consumer at that time was able to convince himself, and with which many even expressed their satisfaction. Chemical examinations were made repeatedly by Messrs. J. A. J. Van den Ven and P. A. Giltay, of this place. Their reports were regularly sent to the burgomaster and aldermen, and though it was evident to each expert that the figures obtained showed fully the improvement guaranted in the contract, I still thought it desirable, when at length, in my own judgment, the purifier fulfilled all the requirements of the contract, to propose to these gentlemen a final examination, and to ask for their opinion on the working of the purifier in connection with the guarantee given in the contract.

"To this end I submitted to both the gentlemen on 10th June last a sample of the very thick river water, and at the same time one of the water filtered at the guaranteed rate of speed. **Their reports, of which copies were sent to the burgomaster and aldermen, were both, without reservation, favourable. They have not hesitated to declare that the method of purification fulfils the conditions specified in the contract.** Repeated microscopic examinations by both gentlemen showed that the water obtained, when regarded also **from a microscopic point of view, was remarkably improved.** . . . . . . I think I must not end this Report without a word of compliment to the contractors and their engineers for the loyal way in which they have fulfilled the stipulations of the contract, whereby my task as engineer has been made much easier. Thanks to their energy, the High-pressure Water Supply can now look forward with confidence to an increase in the water consumption, and **will be in a position continually to deliver a sufficient quantity of good and pure water without the undertaking being too much burdened by the interest on the capital required for it.**"

V. THE OSTEND TRIALS.

The Bruges Canal.

The Town of Ostend, in Belgium, had for many years severely felt the want of a sufficient supply of potable water. The "Canal de Bruges" was the only source affording with any degree of certainty the quantity of water required, but the utilisation of it was impossible owing to its periodical pollution by extraneous waters. The canal is fed by the River Escaut, which is liable to contamination from the waters of the Espierre, a stream flowing through the great wool-washing districts of Roubaix and Tourcoing, on the French frontier. In the spring of 1886 the Communal Council of Ostend voted a sum of £400 to meet the expenses of a thorough trial of the iron purification process as applied to the canal water. A 3-inch Anderson's Purifier, lent by the makers, was erected near the village of Jabbeke, on the banks of the canal, some nine miles above Ostend, and a small sand filter, 150 square feet in area, was constructed alongside it. In addition to the polluted waters of the Espierre, those of the Lys—which, owing to the flax-retting carried on in it, is probably the foulest stream in Belgium—were being diverted into the canal to permit of the construction of a new siphon through which they will eventually flow. The trials were commenced in August and continued until winter set in, being carried out under the very unfavourable conditions mentioned.

In February 1887 the City Engineer, M. E. de Cuyper, published a Report embodying those of Professor Swarts, of Ghent University, and Professor Kemna, of Antwerp, acting respectively for the authorities and for Messrs. Easton and Anderson.

After giving a table of analyses of samples taken at various periods during the experiments, Professor Swarts says :—

"I think I may dispense with discussing here the process of purification of Messrs. Easton and Anderson. I have studied this process, in collaboration with several chemists of Antwerp, in a work addressed in 1885 to the Communal Administration of Antwerp, and of which I have the honour to send you a copy.

"When one compares the result of the analyses of the waters of the Bruges Canal with those which the same water gives after filtration, one acquires the conviction that **purification by iron improves this water in a remarkable fashion.** Before filtration it is thick, yellowish, almost opaque, when examined through a depth of 60 centimetres ; all kinds of lower organisms are seen swimming in it, and when kept for several weeks in a well closed and brightly lighted bottle, confervæ, small crustacea, &c., are seen to develop in it as in a miniature aquarium. I did not think fit to taste it. After filtration over iron the water becomes **absolutely limpid and brilliant** ; when examined through a depth of 60 centimetres it is of perfect transparency, and has a faint greenish tint. Its **taste is fresh and agreeable,** and, after keeping under the conditions described above, there shows itself at the most a slight greenish deposit, due probably to microscopic algæ, but which may also be seen to develop in bottles of distilled water in the laboratory."

Professor Kemna's Report, which follows that of Professor Swarts, fully endorses the conclusions of the latter, and M. de Cuyper adds :—

"To the two reports and note which you have just read, I think **I have nothing to add in order to convince you of the efficacy of the process,** as to which I expressed my conviction in my previous reports. There is, however, one point to which I must call all your attention ; it is the state of the canal during the period of the trials. Since the middle of July the waters of the Bruges Canal have been contaminated by the waters of the Escaut. This contamination, due to two causes, the retting of flax in the waters of the Lys and the discharge of the polluted waters of the Espierre, lasted until the middle of November, and it was only at that time that the canal returned to its normal state. I will not hide from you that, in the presence of these facts, I hesitated a moment in continuing to propose to you the Bruges Canal as a source of supply. In fact, in spite of the assurance

I had of the efficiency of the Easton and Anderson process, I did not conceal from myself the difficulty which there would be in making the population understand that it was possible to render this black and stinking water, in which all the fish were dying, potable and fit for every use."

In order to further satisfy the authorities and the public, the trials were recommenced at M. de Cuyper's request in the spring of the following year. The canal water was worse than before, but so successful was the second experiment, that instead of lasting two months, as at first intended, the purifier was kept at work during the whole of the very dry summer of 1887, so that the purified water might be sent daily into Ostend and supplied for drinking purposes to any who chose to fetch it.

The municipal authorities are perfectly satisfied as to the possibility of utilising if necessary the polluted waters of the Bruges Canal for the supply of their town, and it is probable that works will be designed on this scheme should the Belgian Government consent to the canal water being taken by the municipality.

VI. THE LEA BRIDGE TRIALS.

River Lea.

The following Report of the very important experiment made on a large scale at the Lea Bridge Works of the East London Waterworks Company shows that, by means of the Revolving Purifier, **the water supply of London, drawn from the Thames and the Lea, may be rendered as brilliant in appearance and as pure in quality as the best spring water.**

An apparatus delivering 500 gallons per minute was erected and kept at work for a lengthened period in connection with one of the permanent sand filters of the Lea Bridge Pumping Station. In their Report to Mr. W. B. Bryan, Engineer to the Company, dated October 28th, 1885, after enumerating certain difficulties which had to be overcome before the sand filter could be brought to work exclusively with the purifier, Messrs. Easton and Anderson say :—

> "The proper quantity of iron in relation to the size of the apparatus, the speed at which it is driven, and the quantity of water passing through it per minute, having been ascertained, samples have been taken for examination and analysis, and the results appear to be extremely satisfactory. **As to colour,** as seen in the usual two feet tube, **there is a great improvement as compared with samples taken on the same day from the Company's filtered water reservoirs,** nothing but a faint apple-green tint remaining; whilst, what is of more consequence, **the amount of organic matter,** represented especially by the so-called albumenoid ammonia, **is greatly reduced,** and is brought down, in fact, to a point beyond which the purest waters never pass."

The Report concludes with the following table of analyses, in which the progressive improvement of the sand filter, due to the coating of the sand with ferric oxide, is well exemplified :—

		Free.	Ammonia Albumenoid.
Samples taken 1st Oct., 1885	Company's ordinary water	·040	·040
	Purified water	·015	·020
Samples taken 9th Oct., 1885	Company's ordinary water	·010	·030
	Purified water	none	·010
Samples taken 13th Oct., 1885	Company's ordinary water	·010	·030
	Purified water	none	·010

"The samples taken on the 1st October were not very good, but those taken after that date, when the apparatus was in full work, show a **degree of purity which leaves nothing to be desired.**"

It should be added that for these trials a 12-inch apparatus was used, capable of purifying 954,100 gallons per 24 hours. The experiment was therefore made under the exact conditions of working on the large scale.

VII. THE SEINE WATER.

River Seine.

A 1½-inch Revolving Purifier has been constantly at work since the summer of 1886 at the ironworks of the 'Société des Anciens Établissements Cail,' situated on the Quai de Grenelle, Paris. The Seine water at this point is turbid and polluted by numerous sewers and waste water discharges. A few minutes' contact with iron in the Revolving Purifier render this water beautifully bright and perfectly pure. The Société Cail utilise the purified water for the supply of the dwellings at their works. Analyses made by Professor Kemna, in Antwerp, in October 1886, of samples from the Cail Company's works gave the following results:—

Seine water.	Organic matter.	Free Amm.	Alb. Amm.
Filtered through sand only	0·058 grs.	0·40 mill.	0·16 mill.
Purified by iron	0·025 ,,	trace.	0·06 ,,

The Seine water before and after treatment in the Revolving Purifier was analysed by Professor Marié Davy, the eminent head of the Montsouris Observatory, and Consulting Chemist to the City of Paris. In this Report, dated 12th December, 1886, Professor Marié Davy states that, by his method of analysis, the natural river-water contained at that period no ammonia, so that he was unable to appreciate the effect of the Revolving Purifier process in this respect. He found, however, that Seine water purified by iron and filtered contained only half as much colour as Seine water simply filtered; also, that the oxidisable organic matter was reduced 40 per cent. He adds:—

Clichy Sewer.

"The quantity of organic matter contained in the water still seeming to us too small, **we operated on two occasions on some water drawn from the main-sewer at Clichy,** and filtered afterwards through paper. We have arrived at the following results:—

I. Sewer water, unpurified	25·1
,, ,, purified by cast-iron borings	2·9
Reduction, 88 per cent.	
II. Sewer water, unpurified	45·0
,, ,, purified by cast-iron borings	6·1
Reduction, 86 per cent.	

"We think that this proportion must change with the nature of the organic matter and its quantity."

NOTE.—Much of the information given in this circular is extracted from the pamphlet entitled 'Three Years' Experience of Water Purification by means of Iron in Anderson's Revolving Iron Purifier,' by E. Devonshire, Assoc. M. Inst. C.E. This pamphlet can be obtained at the Offices of the **Revolving Purifier Company, Limited, Dock House, Billiter Street, London, E.C.**

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